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REPORT

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"EFFICIENCY OF DIGITALIZATION OF FEEDING PROCESSES IN PIG BREEDING"

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**ABSTRACT**

Report 38 pp., 4 pic., 10 references, 3 tables, 1 app.

AGRICULTURAL PRODUCTION, PIG BREEDING, INTENSIFICATION, INNOVATIVE DEVELOPMENT, DIGITALIZATION, ECONOMIC EFFICIENCY, FEEDING RATION, FEED PRODUCTION, PIG PRODUCTION GROWTH, PIG PRODUCTION QUALITY

The purpose of the work is to theoretically justify the need for intensive development of pig breeding in the Kostanay region, to develop recommendations for the methodical and practical importance of the introduction of digital technologies in the processes of feeding pigs, providing high quality pig products and increasing its competitiveness in the border market in the context of the interregional spatial integration of Russia and Kazakhstan.

The object of the research is the branch of pig breeding of farms of the Kostanay region, based on the use of innovative digital technologies.

At the first stage of the work, the analysis and systematization of the main problems in the development of pig breeding in the Kostanay region under modern economic systems were carried out (statistical data were processed, a questionnaire was conducted).

We used such methods as the analysis of statistical information and scientific literature in order to justify the preferential directions of the sequential intensification of individual processes of production of pig-breeding products.

The results obtained can be used to develop practical recommendations on the digitalization of the feeding process in pig breeding.

**DEFINITIONS, DESIGNATIONS AND ABBREVIATIONS**

The following terms and definitions are used throughout this report:

Fodder production - is a branch of agriculture that includes organizational, economic and agrotechnical activities carried out to provide animals with food during the pasture and stall period.

The ration of feeding - is a daily feeding dacha, composed of various foods, taking into account the needs of animals for nutrients.

Pig breeding - is a livestock industry that breeds and uses pigs.

Agricultural production - is a set of economic activities in the field of cultivation, production and processing of agricultural products.

Digital livestock farming - is a set of solutions aimed at a systematic increase in production efficiency through the use of information and communication systems, as well as technical means that ensure targeted use of resources and precise control of production processes.

Economic efficiency - is a value determined by the ratio of the results of human activity, the production of products (goods or services) and the cost of labor and funds for production.

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# INTRODUCTION

Sustainable development of the pig farming industry of the Kostanay region, based on the use of innovative digital technologies, which determine the high quality of clear products, which can become one of the key factors of the transition to a higher level of the interregional spatial integration of the border territories of the two states - the Russian Federation and the Republic of Kazakhstan.

Purpose: Theoretical substantiation of the need for intensive development of pig breeding in the Kostanay region, implementation of the development of recommendations for the methodical and practical importance of the introduction of digital technologies in the processes of feeding pigs, ensuring the high quality of pig products and the growth of their competitiveness in the border market in the conditions of the interregional spatial integration of Russia and Kazakhstan.

Tasks for the reporting period:

To analyse and systematize the main problems in the development of pig breeding in the Kostanay region under modern economic conditions.

To substantiate the preferential directions of the sequential intensification of individual processes of the production of pig-breeding products.

The scientific value ofthis project lies in the application of innovative digital and other technologies in the pig industry, necessary to increase profitability.

The development and implementation of the project on digitalization of pig feeding will not only allow to increase the production of pig products, but also to bring the quality of pig products to the level of the advanced regions of the country and abroad and increase its competitiveness in the border market.

The use of digital technologies for the development of rations for feeding pigs, the possibility of compiling them in the shortest possible time, directly at the test, taking into account the specific features and conditions of management, distinguishes this project from existing analogues and determines its novelty.

The theoretical significanceof the research lies in the substantiation of the preferential directions of the sequential intensification of individual processes of the production of pig-breeding products.

Practical significancelies in the development of practical recommendations for the implementation of digitalization in the feeding process in pig breeding and the possibility of reducing the negative and often irreversible impact on the ecology and the environment as a whole as well as reducing water consumption, increasing the efficiency of energy conservation and efficiency.

Giving modern pig breeding a new impetus for development puts new priorities, demands and opportunities. The reduction of the impact of harmful factors on the environment, an increase in the efficiency of the use of resources, and the provision of acceptable and comfortable conditions when keeping pigs are among those opportunities.

The development of practical recommendations will make it possible to make the activity of the agro-industrial complex in matters of breeding pigs more efficient and optimal.

A prerequisite for this is the observance of the requirements, which are based and flow from technological indicators, as well as the solution of the problems of increasing the efficiency of energy use, more active introduction of import substitution, which implies increasing the competitiveness of domestic enterprises in this industry. The successful solution of these tasks, along with the improvement of the ecological state, which in itself is very important, will also allow to increase the efficiency of the work of the enterprises of the agro-industrial complex due to the provision of a qualitatively new approach to the content of agricultural activities.

# MAIN PART ABOUT SRW

# 1 Basic approaches to research and its objectives

Presently, in the structure of Kazakh livestock breeding, the most "lagging" industry is pig breeding, which is explained, first of all, by the lack of organized markets for the sale of products of the pig breeding industry in our country. However, in the context of the development of the interregional spatial integration of Russia and Kazakhstan, the effective organization of the production of pig products can make an important contribution to the development of the export trade organized between the border territories of both countries.

In this regard, the expected results of the project are methodological recommendations for solving economic and organizational problems associated with the need to reduce costs and improve the quality of products of pig farms.

The results of the project will be of interest both for the households of the population engaged in auxiliary pig breeding, as well as for the organizers of large pig farms - potential exporters, who, in the future, plan to actively participate in the cross-border trade.

The methodological basis of the design research will be made up of the principles of a systematic approach, as well as such methods and techniques that are general scientific, such as a method of scientific abstraction, analysis and synthesis, structural and functional analysis, a combination of historical and logical approaches, computational and economic-constructive, statistical etc.

# 2 Overview of the methodological framework for the study

# 2.1 The main directions of studying the effectiveness of the feeding process in pig breeding

It is worth noting that various issues of feeding in pig breeding are devoted to the works of a number of researchers both foreign and domestic such as I.Y. Agneeva, O. V. Aseeva, N.S. Geghamyan, I.V. Zorina, V.D. Kabanova, E.A. Kovalenoka, M.M. Lapshina, N.N. Mironova, N.F. Mosunova, A.K. Pastukhova, A.P. Svyatogora, B.C. Sorokin, K.B. Sosnovsky, A. Valle Zarate, Dunkin A.C., Emrich K., Kaufman B., Lemke U., Taverner M.R., Thuy L.T., Weller J.I. etc.

Let us dwell on an overview of some of the studies that formed the methodological base of the project. In pig breeding, three technological schemes of production are used: continuous production, cyclical-level and level production systems. The basis of the industrial management of pig breeding is in-line production, which is based on the following organizational and technological principles: uniform, year-round farrowing of sows in the course of a year; sequential formation of technological groups of pigs; rhythm of production; separate-shop organization of labor; separate content of each technology group in a separate isolated technology section; implementation of the principle "everything is free - everything is busy"; compliance with the sanitary gap; specialization of buildings, equipment for production purposes; complex mechanization and automation of production processes; standardization of products [1-2].

An important factor in the industrial production of pork is the specialization and standardization of the livestock of sows. Their live weight, timing of insemination, stimulation, synchronization, level of productivity, breed should be of the same type. Uniform farrowing makes it easier to process products and eliminate the uneven load of the processing industry.

With flow technology, production processes are developed by taking into account the rhythm of production. For farms of low power, the most appropriate rhythm is seven days. The seven-day production rhythm is a multiple of the astral period of the sows (twenty-one days), as a result of which three complete technological groups can be assembled during this period.

In recent years, a deviation from the seven-day rhythm of production has become widespread towards its decrease to five-six days, with a goal to increase the capacity of pig-breeding enterprises.

The flow technology is recommended for use in pig farms with an annual production volume of less than twelve thousand heads of fattening shepherds.

A cyclic-round farrowing system is used in small farms, which makes it possible to reduce the need of livestock for stowage places in comparison with the tour system and to maximize the biological needs of pigs.

# 2.2 Research on the effectiveness of the pig feeding process in Kazakhstan

Several scientists have devoted to the study of the processes of feeding pigs in Kazakhstan such as E.K. Kaskenov, Zh.S. Akanov, K.A. Sarbaev, G.V. Ustenov and others.

In Kazakhstan, several systems of pig housing are used, depending on the number of phases. Three-phase technology is a traditional system, when, after the suckling period, the piglets are weaned from the sows, transferred to the rearing group, and then to the fattening group. Adopted in most specialized pig farms and large industrial complexes, this rearing technology provides for the consistent keeping of piglets in three types of premises.

Two-phase technology comes in two variations. The classic, widely used in pig breeding in the USSR, is that after weaning, the piglets remain in the same pen, in the same group, until the transfer of ᴎх to fattening. Since the nest of piglets is not disbanded and not united, the factor of "new community" is eliminated. The disadvantage of this system is the need for a large amount of the most expensive equipment - pens for suckling pigs.

In the last decade, two-phase technology has been reborn with the Wean-to-Finish technology, whereby piglets, after weaning, are transferred directly to the feeding area, where they are fattened before transfer to slaughter. The main advantage of this system is the elimination of stress from moving and mixing pigs [3].

The opposite of the two-phase technology is the four-phase technology, in which an intermediate stage is introduced between the stages of growing and fattening - pre-feeding. The advantage of this system is a higher level of hygiene in the sections and more specialized conditions for growing specific age groups of piglets.

# 3 Stages, tasks, and methods of research

# 3.1 Research Objectives

Considering the total duration of the project, its goal, tasks and expected results, it is advisable to distribute the entire volume of the proposed work to several stages (the first-second stages - 2020 year, the third-sixth stages 2021 year):

The first stage: the analysis and systematization of the main problems in the development of pig breeding in the Kostanay region under modern economic conditions.

The second stage: the substantiation of the preferential directions of sequential intensification of individual processes of production of pig-breeding products.

The third stage: the identification of the relationship between the ration of feeding pigs and the quality of pig products.

The fourth stage: the choice of an effective feeding strategy as the primary task of the pig breeding enterprise.

The fifth stage: the development of practical recommendations for the implementation of digitalization in the feeding processes in pig breeding.

The sixth stage: the development of a program for calculating the ration of feeding pigs.

The set research objectives contribute to the implementation of the proposed work at all stages.

# 3.1.1 Research Tasks

The scientific and research tasks include:

- To identify, analyze and systematize the main problems in the development of pig breeding in the Kostanay region under modern economic conditions (in particular, a retrospective analysis of the development of the pig breeding industry in the region and in the Republic of Kazakhstan as a whole, the establishment of factors that restrain the intensive development of pig breeding, the identification of negative trends leading to a decrease profitability of production and sale of pig products).

- To describe the technological processes currently used in the considered branch of agriculture and determine the best available technologies.

- To substantiate the preferential directions of the consistent intensification of certain processes of production of pig-breeding products, ensuring the growth of its competitiveness in the agricultural market of the Russian-Kazakh border area.

- To establish the relationship between the ration of feeding pigs and the quality of pig products.

- To substantiate the choice of an effective feeding strategy as the primary task of a pig breeding enterprise.

# 3.1.2 Practical Tasks

The practical tasks include:

- To develop practical recommendations for the implementation of digitalization in the feeding processes in pig breeding and substantiation of the effectiveness of the adopted innovative solutions in the context of the active development of the interregional spatial integration of Russia and Kazakhstan.

- To substantiate the available information about new technological and technical solutions aimed at increasing energy efficiency, saving resources, reducing emissions of pollutants, efficient handling of waste, intermediate and by-products.

- To develop a software for calculating the ration for feeding pigs.

- To publish one article in a peer-reviewed scientific building on the scientific direction of the project, which is included in the first, second or third quartiles in the Web of Science database and (or) having the CiteScore percentile in the Scopus database no less than thirty five.

- To publish one article in the journal "Problems of the Agricultural Market" recommended by CCSES.

# 3.2 First stage of research

The first stage of the project dealt with the analysis and systematisation of the main issues of the development of pig breeding in the Kostanay region under modern economic conditions.

According to the official statistics for 2019, in comparison with 2018, there was a decrease in the average number of pigs per months by 1.2% or by 1,3 thousand; while nine months of 2020 saw a significant increase on average by months compared to 2019 by 2.4% or three thousand in the Kostanay region. At the same time, the analysis of a longer period shows a decrease in the number of pigs from 244.7 thousand (at the end of 2003) to 165.8 thousand (at the end of 2019) or 23.3% in the Kostanay region. Currently, according to statistical data and the results of a questionnaire survey of agricultural producers in the Kostanay region, all pork production can be divided into two sectors: peasant (farm) households and individual entrepreneurs (medium production, less than twelve thousand heads of fattening) and production in natural subsidiary farms and small farms [9].

In the Republic of Kazakhstan, pig breeding has a great potential. In the structure of meat production, it occupies the second place, whilst in the structure of consumption it takes the third place. Thus, pork should be considered as a strategic product that ensures the food security of the country. Kazakhstan is the largest grain producer, which should stimulate the development of the pig industry. Further development of pig breeding is the most important factor in providing additional workers for food in related industries. In the world, pig breeding is developing at a rapid pace and is one of the main relatively expensive food sources of the population. This is facilitated by the economic efficiency of the industry, which is due to the early maturity of pig breeding and low feed costs per unit of production. In terms of feed conversion, pig breeding surpasses all other livestock industries, except for poultry [4].

The livestock of pigs is mainly concentrated in the private farmsteads of the population (66.5% is the share of private farms), where there is a primitive technology for raising and fattening animals. The bulk of the pig population is concentrated in the North Kazakhstan, Kostanay, Akmola and Almaty regions. More than 68% of pork is produced in Kostanay, North Kazakhstan, and Almaty. Pig breeding in our country is currently still far from the level of efficiency of economically developed countries and, consequently, the competitiveness of pork in the world market. If the average daily weight gain of fattening pigs in developed European countries falls into the range of 700-800 grams, in Kazakhstan, it achieves only 350-400 grams in agricultural formations.

The analysis of the balance of production, consumption, export and import of pork in Kazakhstan shows that the production of pork in agricultural formations for the period from 2014 to 2019 increased by 60% and amounted to 23.9 thousand tons. At the same time, while in 2014 the level of consumption in the Republic reached 198.2 thousand tons of pork; in 2019 the level grew to 204.6 thousand tons, in other words, the consumption growth amounted to 3% in six years. The volume of consumption of imported products in the domestic market is about 6% of the total consumption. The specific gravity of the consumption of self-produced pork is more than 94% of the total consumption. At the same time, currently, the existing capacities of the pig farm are not used in full, estimated 60 - 70%. The opportunities for pork production in Kazakhstan are enormous. In this regard, our task is to radically revive the pig industry, transfer it to an intensive industry and ensure that it can provide cheap competitive products, respectively, become a high-tech production, comparable in efficiency with the pig breeding of countries such as Denmark, Canada, Hong Kong, France, and Germany [5-6].

Pedigree pig breeding as profitable production of pork is possible only with widespread use for its production of highly productive, with stable genetic potential and well adapted to industrial technology of animal breeds. At present, in Kazakhstan, large white breed of pigs are mainly bred, as well as landras, but these breeds do not correspond to the consumer market. For industrial production and breeding in small, specialized farms, the promising hybrid is a hybrid young stand obtained from the crossing of specialized pigs, types and breeds of pigs, from bred for a high yield of lean meat.

Table 1 - Production, export, import and consumption of pork

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Indicators | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Production, thousand tons | 193.9 | 206.2 | 208.9 | 206.0 | 213.6 | 192.7 |
| Including: in ACB | 14.9 | 18.0 | 17.4 | 17.9 | 23.1 | 23.9 |
| Export, thousand tons | - | - | 0.02 | - | 0.26 | 0.15 |
| Import, thousand tons | 4.3 | 9.1 | 8.1 | 7.5 | 9.3 | 12.0 |
| Consumption of 1 person / year, kg | 12.4 | 13.5 | 12.6 | 14.1 | 13.9 | 12.8 |
| Share of import, % | 2.2 | 4.2 | 3.7 | 3.5 | 4.2 | 5.9 |
| \* according to the data of the Statistics Agency of the Republic of Kazakhstan | | | | | | |

As the main mother breed, they use a large white, as a paternal one - landras, duroc or other clear breeds. Hybrids are widespread in all areas in the world we live in, it is impossible to get meat pork without hybridization. Our agricultural producers carry out breeding work with pigs in the direction of improving clear qualities, reducing feed costs per unit of growth and maintaining a strong constitution. Large white pigs act as a mother form for obtaining commercial hybrid and hybrid animals. Animal breeds (landras) are used for crossbreeding in order to obtain hybrid animals with good clear qualities, as well as for hybridization and breeding of new breeds. The factors that restrain the intensive development of pig breeding have been identified, negative trends have been revealed that cause a decrease in the profitability of the production and sale of pig products: a number of main factors have been identified that lead to negative consequences associated with environmental changes in the surface of pigs - this is increasing emissions of pollutants into the atmospheric air from stationary and mobile sources, waste disposal with disruption of existing sanitary feeds, low level of decontamination, processing and reuse, land degradation caused by natural disturbances and a decrease in biological diversity associated with this to self-regulation.

A serious negative factor hindering the development of pig breeding in the region and the Republic of Kazakhstan can become infectious diseases, which lead to large losses of livestock (20-35% of the total number of animals). In 90% of farms, the problem of reproduction arises due to the illiterate feeding of pregnant sows. Overfeeding is most common, leading to obesity in sows of various breeding. At the same time, there are problems of an increase in the number of neonatal pigs, prolonged farrowing, endometritis, estitis, agalactia and hypogalactia, a significant increase in the mortality of piglets, a decrease in weaning weight, the absence or delay of hunting after weaning, abortion and, as a consequence, a decrease in life-long productivity.

One of the main reasons for the low productivity of animals in pig breeding is unbalanced feeding. The completeness of the compound feed is determined by the presence in it of energy, protein, amino acids (especially essential), vitamins and minerals in the optimal amount for each age and gender group of animals.

The quality of compound feed affects not only the productivity of animals, but also significantly affects the composition of animal waste and the environmental aspects of their storage and use. For example, the maximum amount of phosphorus in waste used for fertilizing agricultural land is 25 kg per hectare, and the concentration of phosphorus in waste can vary depending on the composition of the ration within a very wide range.

There are similar restrictions on the content of ammonia, 135 kg of which is a critical value when applying organic fertilizers per hectare.

Oversaturated compound feed for phosphorus and protein deficient for lysine and sulfur-containing amino acids will lead to a significant increase in the content of phosphorus and ammonia in the effluent. And this, in turn, can lead to a violation of the ecological balance in soils when using such an organic fertilizer and especially a liquid fraction for irrigation.

The transition in the last 30-40 years in the leading countries of industrial pig breeding to the production of meat pork has determined new requirements for the quality and nutritional value of feed, especially for lactating sows and young pigs and, in general, for the rationing of nutrition.

The basis for the effective use of feed resources for pig breeding in Kazakhstan is the technology of their storage, preparation and distribution and the improvement of the nutritional norms of rations.

At present, when designing pig breeding enterprises, preference is given to complete feed. The use of granulated mixtures is also more effective than loose mixtures in many respects. The multicomponent type of feeding, which was widely used until recently, in which, along with legumes, skim milk, cake and meal, animal waste, juicy feed and potatoes that require additional processing are used, it is distinguished by a high resource intensity.

The thermophysical effect on feed contributes to an increase in the availability of carbohydrates, protein, amino acids and trace elements. However, vitamins are partially destroyed in this case.

The addition of deficient synthetic nutrients in the process of compound feed preparation has become a common practice in the implementation of the planned feeding system at pig breeding enterprises [7].

The question of the use of dry or liquid (wet) feeding continues to be difficult. This problem has been studied for many years by the leading scientific centers of pig breeding in many countries of the world. The main condition for the transition to wet (liquid feeding) should be the availability of cheap “wet” components of the diet (milk processing waste, crushed waste from food enterprises and fish factories, brewer's grains, root crops of our own production, etc.).

In this case, you should carefully calculate all capital investments and energy costs associated with the preparation of liquid feed. Often, a small gain in increasing the use of feed nutrients (3-5%) is "eaten" by additional energy consumption for cooking, normalizing the microclimate of the premises, increasing the volume of industrial effluents, their further separation into fractions and use.

There are two types of feeding - dry and liquid. Dry feeding is now widely used in the reconstruction and construction of new pig breeding enterprises. The main advantages of the automated distribution of dry food include efficiency and resource saving, ease of use of equipment, a significant reduction in the proportion of manual labor, the ability to work in automatic mode from the built-in programmer. Modern equipment for dry feeding through feeders, combined with drinkers, makes it relatively easy to service the pig herd; feed losses and contamination are reduced. Any dosing regimen is possible.

Liquid feeding is currently used in the reconstruction and construction of new pig farms. At the same time, the pigs are fed with prepared nutritionally balanced compound feed, previously diluted with water (in a ratio by weight of compound feed and water no more than 1: 3). Feeding with mushy feed is also used [8].

The choice of the type of feeding depends on the direction of the farm, the nature of the feed base, sources of concentrated feed and other factors.

Each pig-breeding farm and complex provides storage facilities (warehouses) for feed. The capacity of warehouses and feed storages is determined by the number of pigs, the duration of the period of use of the feed, the composition of rations and the bulk density of the feed.

On industrial complexes, in the immediate vicinity of which there is a feed mill, the stock of concentrated feed can be reduced to 10 calculated days.

Inter-farm pig farms and complexes can have an increased supply of concentrated feed, the shelf life of them in each case is determined by the design assignment.

Direct feeding of animals is made from feeders. The sizes of the feed-flies in cleanliness (without taking into account the structures) and the feeding area are given in table 2. Deviation from the sizes indicated in the table is allowed within 5%.

The total length of the feeders is determined from the calculation of feeding all pigs in one shift - one head per one feeding place. With constant access of pigs to dry feed, it is allowed to take up to three heads per one feeding place.

For the manufacture of feeders used dense, moisture-proof and harmless to animal materials, easy to clean and disinfect, providing a smooth surface texture.

When analyzing the technologies used in intensive pig breeding, a survey of 120 pig farms was carried out. The processing of industry questionnaires showed that pig breeding enterprises have machine and technological equipment from various manufacturers / suppliers. So, in the questionnaires, respondents noted: serial domestic and foreign equipment of the period of the 70s-80s of the last century 5.4%, most of the enterprises 94.6% are equipped with modern foreign equipment.

Table 2 - Feeder sizes and feeding area for different production groups of pigs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of equipment | Size, cm | | | Feeding front per head, minimum |
| Width | | Headboard height |
| on the top at the level of the front board | at the bottom with rectangular and trapezoidal sections |
| Dry food troughs (with humidification in troughs) | | | | |
| - for boars and sows | 50 | 50 | 25 | 45 |
| - for fattening and replacement shepherds | 50 | 50 | 25 | 30 |
| - for weaning pigs | thirty | thirty | 15 | 20 |
| Wet feed troughs | | | | |
| - for boars and sows | 40 | 30 | 20 | 45 |
| - for fattening and replacement shepherds | 40 | 30 | 20 | 30 |
| - for weaning pigs | 25 | 20 | 15 | 20 |
| - for suckling piglets | 15 | 10 | 10 | 15 |

 The main production process for obtaining marketable pig products is divided into reproduction, rearing and fattening / growing cycles, in accordance with which the reproduction, rearing and fattening workshops are organized.

The first stage: Reproduction. It includes the maintenance of breeding boars, obtaining sperm from them for insemination and sale, preparation of sows and gilts for insemination, direct insemination, gestation period, preparation for farrowing, farrowing and suckling period. The first stage of production includes an insemination workshop, a gestation workshop, a survey workshop.

Second stage: Rearing. The rearing period of piglets after weaning. They grow with a weight of 6-8 kg and are transferred to the growing area, where they stay for seven to eight weeks or until they reach a weight of 25-30 kg. Piglets are kept in group pens.

The third stage: Fattening. Fattening is raising pigs to the established weighing conditions. When the piglets reach a mass of 25-30 kg, they are transferred to the feeding area, where they are kept for three months in group pens. Piglets weighing 100-110 kg are sent to the meat processing plant, many pork producers feed pigs up to 120-125 kg.

Breeding - rearing of replacement young animals to replace the main herd of boars and sows. When the piglets reach a mass of 30 kg, they are transferred to the site of replacement young animals, where they are kept in group pens.

The main structural unit of the continuous production of pork is a technological group.

The division of the herd into groups of appropriate age and physiological state allows standardizing the conditions for keeping animals. For example, at the reproduction site, the technological group of sows is formed during insemination and is preserved until the piglets are weaned. In the growing area, piglets obtained from sows of one technological group also form their own technological group, which is preserved during their further setting for fattening. Features of the technological group are in its integrity and high standardization of the population. Technological groups are formed after a certain period of time - the rhythm of produ Architectural and construction solutions of farms and complexes have two versions - single-site (closed cycle) and multi-site (multisite). The first is characterized by the placement of all workshops and plots in separate buildings on one site, for the second - the placement of separate zones for keeping animals at a certain distance from each other (up to several kilometers).

Analysis of the data given in the sectoral questionnaire showed that 30.5% of enterprises belong to single-site complexes, 12.9% to multi-site complexes, for the rest, due to the lack of data, it is impossible to make a conclusion.

In the process of breeding pigs and the production of pig products, all technological sub-processes are interconnected, the physiological state of the uterus pig determines its presence in a certain area of ​​the production cycle.

The questionnaire provided indicators characterizing the reliability and efficiency of the equipment, as well as its impact on the environment.

# 3.3 Second stage of research

At the second stage of the work, the substantiation of the preferential directions of the sequential intensification of individual processes of production of pig-breeding products was made, one of the main reasons for the low productivity of animals in pig breeding in the Republic of Kazakhstan was revealed - unbalanced feeding. The completeness of the compound feed is determined by the presence of energy, protein, amino acids (especially irreplaceable ones), vitamins and minerals in the optimal animal quantity for each age and sex group.

The transition in the last 30-40 years in the leading countries of industrial pig breeding to the production of meat pork has determined new requirements for the quality and nutritional value of feed, especially for lactating sows and young pigs, and in general for the rationing of nutrition.

The basis for the effective use of feed resources for pig breeding in the Republic of Kazakhstan is the technology of their storage, preparation and distribution and the improvement of the nutritional value of rations.

The main tasks of the second stage are:

- Development of practical recommendations for the implementation of digitalization in feeding processes in pig breeding and substantiation of the effectiveness of innovative solutions adopted in the context of the active development of interregional spatial integration of Russia and Kazakhstan.

- Development of a program for calculating the ration of feeding pigs.

At the second stage of the study, promising technologies will be proposed for Kazakhstani enterprises for intensive pig breeding.

1) The system of automatic control and management of the pig breeding complex, which will allow the operation, centralized control and monitoring of a large number of regulators of all production workshops of the enterprise. The system will include centralized management of all controllers, optimizing their capabilities, has a network connection. The control will be carried out using a specially developed computer program.

2) The system of automatic feeding of pigs, which will allow for continuous and accurate accounting of feed freely consumed by each individual animal in group maintenance, consisting of a network of feed stations connected to a personal computer. State-of-the-art interfaces allow remote maintenance, and it is also possible to connect to pig planning databases.

# 3.4 Third stage of research

At the third stage, the preferential directions of the sequential intensification of individual processes of the production of pig products are substantiated. Aspects have been developed to ensure the growth of pig production, competitiveness in the agricultural market of the Russian-Kazakh border area, and the intensification of livestock farming.

A round table with practitioners in the pig industry made it possible to fully use the expert survey method and put it at the heart of the SWOT analysis. The results of the conducted research served as the basis for the development of practical recommendations for the implementation of digitalization in the feeding processes in pig breeding:

1) Scientific and theoretical recommendations on the classification of problems in the development of the pig industry in the Republic of Kazakhstan in the context of the factors causing them, which will allow to establish trends in the development and functioning of pig breeding in Kazakhstan in the future, as well as provide an opportunity to develop directions for the intensive development of pig products.

2) Scientific and methodological recommendations of an organizational nature on the enlargement of agricultural enterprises and a quantitative increase in the number of pigs at individual sites, which, firstly, will reduce costs and other costs for the production of pig products; secondly, it will simplify the task of introducing digital technologies into the production of pig products.

3) Practical recommendations for the digitalization of pig feeding. In particular, on the use of an automated pig feeding system, which includes a network of feed stations connected to a single network with a personal computer, which will make it possible, first, to remotely service the mechanisms of the automated system; second, linking to pig planning databases.

4) Practical recommendations for increasing the productivity of pigs, based on the available feed base and the possibility of using additional feed additives and means.

The development of practical recommendations for the implementation of digitalization will allow to optimize the functioning of pig farms in the agro-industrial complex through the transition to processes based on technological indicators, will ensure the intensification of production processes, will significantly reduce the negative and adverse impact of the industry on the environment, ensure high quality of pig products and increase its competitiveness in international market.

**3.5 Fourth stage of research**

At the fourth stage, a relationship was established between the rations of pigs' cutting and the quality of pig products, and technologies for keeping and feeding pigs were developed.

Based on the results of the study, the article "Rational use of feed as a factor in the growth of animal productivity in pig farms" was published in the journal "Problems of the agricultural market" [10]. The article pays attention to the description and substantiation of the technologies of preparation, storage and distribution of feed used in the intensive type of pig breeding, with an emphasis on rationing and provision of nutrients. The purpose of the publication was to study the development of innovative technologies that are used in the intensive type of pig breeding, helping to reduce the negative impact on the environment, ensuring high quality pig products, and, as a consequence, increasing its competitiveness in the border market in the context of interregional integration of the Republic of Kazakhstan and Russian Federation. Based on the stated goal, the main task was to substantiate proposals that confirm the feasibility and relevance of the introduction of an automatic feeding system for pigs, which makes it possible to keep a continuous and accurate record of feed freely consumed by each individual animal in the conditions of their group keeping:

1) The efficiency of production in the pig-breeding industry is determined by the cost of its production, and above all by the cost of labor and feed.

2) One of the most effective measures aimed at reducing the cost is the system of automatic feeding of pigs, which allows for accurate and continuous accounting of feed, which is freely consumed by each individual animal in their group keeping. Such a system includes a network of feed stations connected to a single network with a personal computer (PC). By means of this PC, the interfaces make it possible to remotely service the mechanisms of the automated system, along with this, it is possible to connect to databases on the planning of pig breeding [9].

3) The software contains a wide range of feeding programs, including those allowing to monitor the health of the pig population, to carry out labeling, recording of zootechnical indicators, keeping records, collecting data and transferring them to the main computer. The automatic feeding system is produced in several modifications.

4) Such systems are widely used in foreign countries in pork production enterprises. Natural, man-made conditions allow the use of such technologies at pig breeding enterprises of the Kostanay region [10], which will ensure the effective use of feed, targeted individual feeding of pigs, taking into account their characteristics, group keeping and free movement of pigs, leading to a decrease in stress and an improvement in their condition , and, as a consequence, an increase in the productive use of both the fodder base and pig products. One feeding station can serve 60-80 sows.

5) Thus, it is through the digitalization of agriculture that the domestic agro-industrial complex is able to ensure the country's food security, as well as enter the international food market.

# 3.6 Fifth stage of research

At the fifth stage, the choice of an effective feeding strategy was substantiated according to the main principle - obtaining maximum profit at minimum costs. The article "Automatic pig feeding system: Efficiency" was prepared and accepted for publication in the peer-reviewed scientific journal Pakistan Journal of Zoology (ISSN 00309923, Q3, percentile 43, https://researcherslinks.com/journal/Pakistan-journal-of-zoology/20 ).

# 3.7 Sixth stage of research

At the sixth stage, practical recommendations were developed for introducing digitalization into the feeding processes in pig breeding:

1) Scientific and theoretical recommendations on the classification of problems in the development of the pig-breeding industry of the Republic of Kazakhstan in the context of the factors causing them.

This study was carried out to identify the problems existing in the industry, analyze them, systematize and classify them in the context of negative influencing factors. The result of the study was the classification of pig breeding problems developed by the authors, including organizational, technical, and technological, economic and personnel factors that hinder the effective development of the industry.

The proposed classification of problems allows not only to establish trends in the development and functioning of pig breeding in the agro-industrial complex of the Republic of Kazakhstan, but also provides an opportunity to develop directions for the effective development of the pig breeding industry. The identified problems confirm the need for a new, scientifically grounded activity of pig farms, which should be based on the automation and digitalization of all production processes.

Based on the results of the analysis, a classification was drawn up of the problems that hinder the profitable development of the pig-breeding industry in the agro-industrial complex of the Republic of Kazakhstan (Table 3).

The classification of the problems made it possible to establish trends in the development and functioning of pig breeding in Kazakhstan, provided an opportunity to develop directions for the effective development of the pig breeding industry.

The classification of the identified problems of the pig industry in the context of the factors causing them indicates the need to use highly efficient, ultra-modern production technologies that reduce resource losses and gain high profits. In this regard, digital technologies for agricultural production are the most appropriate.

Table 3 - Classification of the problems of the development of the pig-breeding industry in the Republic of Kazakhstan in the context of the factors causing them

|  |  |
| --- | --- |
| Group of problems | Content |
| Organizational | −    production of the predominant part of pig products in households, which leads to an extremely low level of mechanization and intensification of the industry;  −    lack of organized markets for the sale of pig products;  −    weak legislative base;  −    insufficient development of cooperative forms of management in pig breeding. |
| Technical and technological | −    lack of own feed shops and feed factories in pig farms, failure to comply with the technology of feeding pigs;  −    suboptimal structure of the pig population, in particular, the excess of the proportion of sows in comparison with the optimal indicators;  −    the use of outdated and ineffective methods of breeding and selection work;  −    lack of proper zootechnical records;  −    low level of application of innovative, digital and energy-saving pig breeding technologies. |
| Economic | −    insufficient financing of pig-breeding projects of agricultural companies from the state and banking structures;  −    lack of economic interest among agricultural producers in the development of pig farming;  −    a significant reduction in the number of pigs and production volumes;  −    lag in the growth rate of pork prices in comparison with the growth rate of prices for other types of meat in the meat market. |
| Personnel | −    lack of qualified personnel;  −    low level of qualifications of personnel. |

2) Scientific and methodological recommendations of an organizational nature for the enlargement of agricultural enterprises and a quantitative increase in the number of pigs at individual sites.

One of the ways to solve the existing problems in the pig industry is to develop a cooperative sector of agricultural producers. Today the number of large pig-breeding enterprises in Kostanay region is insignificant. But on their basis, new organizational structures can be created according to the principle of "anchor cooperation".

Meat processing enterprise

Agricultural enterprise (LLP)

Organization of automated pig feeding

Farms

Households

IE

Farms

IE

Households

breeding boars

breeding boars

offspring

live weight

offspring

live weight

VERTICAL COOPERATION

HORIZONTAL COOPERATION

HORIZONTAL COOPERATION

Figure 1 - Model of "anchor cooperation" in pig breeding

 An approximate scheme of cooperation can be built as follows: LLP, on the basis of which a specialized fattening department was created, acquires breeding boars, leasing them to agricultural cooperatives, which may include both peasant (farm) farms, individual entrepreneurs, and small households of the population ... Then the limited liability partnership acquires the offspring of such boars at a negotiated price, fattens them in appropriate conditions to the required weight and sells them to the meat processing plant (Figure 1).

A large meat processing enterprise can act as an "anchor" enterprise.

The simulated conditions of cooperation will provide new opportunities for all its participants (including households), which, by reducing costs and receiving subsidies, will be able not only to increase the number of pigs, but also to strengthen their own raw material base, which will have a positive impact on the quality and competitiveness of pig products.

Thus, the authors propose the use of organizational factors as a way to improve the efficiency of production and sale of pig products. In particular, the development and implementation of various schemes of "anchor cooperation" in the production process will allow small commodity producers - peasant farms and households - to gain access to material resources, including the opportunity to use various services (zootechnical, veterinary, marketing), and will also simplify the task of introducing digital technologies in the production of pig products and will ensure high manufacturability of production by organizing automated complexes for raising and fattening pigs on an industrial scale on the basis of large agricultural enterprises.

3) Practical recommendations for the digitalization of pig feeding, in particular, for the use of an automated pig feeding system. The efficiency of production in the pig-breeding industry is determined by the cost of its production, and above all by the cost of labor and feed. One of the most effective measures aimed at reducing the cost is the automation of the feeding processes of the pig population.

The automatic pig feeding system is an automated system that allows accurate and continuous accounting of the feed that each individual animal freely consumes when keeping them in a group. Such a system includes a network of feed stations connected to a single network with a personal computer (PC). By means of this PC, the interfaces make it possible to remotely operate the mechanisms of the automated system, along with this, it is possible to connect to databases on pig planning issues.

The software contains a wide range of feeding programs, including allowing for monitoring the health of the pig herd, labeling, recording zootechnical indicators, keeping records, collecting data, and transferring them to the main computer. Each feeding station is provided with a controller and associated service equipment, with the help of which the animal is identified, the rate and the feeder are determined, into which a certain amount of feed is supplied. In turn, the feeder has a device for precise dosing of medicines, automatic feed moistening directly in the feeder, with the possibility of combined feeding with crushed corn and whey. The approach to the feeder with just one animal's head is provided by a split, which is adjustable in width for just one animal. A scale can be installed in front of the feeder entrance to enable this system to record the weight of each animal on a daily basis. The automatic feeding system is produced in several modifications.

Such systems are widely used in foreign countries in pork production plants. Natural, technogenic conditions make it possible to apply such technologies at the pig-breeding enterprises of the Kostanay region.

This will ensure the effective use of feed, targeted individual feeding of pigs, taking into account their characteristics, group keeping and free movement of pigs, which will reduce stress and improve their condition, and, as a result, increase the productive use of both the feed base and pig products. One feeding station can serve 60-80 sows.

# 3.8 Seventh stage of research

At the seventh stage, criteria were developed for optimizing diets with a flexible feeding process for animals to maximize production efficiency in various production and economic situations. A test version of the program for calculating the ration of feeding pigs was developed, the program was recorded and distributed between farms of different forms of ownership.

For each group of pigs, it is necessary to select compound feed taking into account their health and condition characteristics.

The algorithm for working with the software consists of the following steps:

1) Prepare nutritionalized ration types for each feeding group. This takes into account vitamins, minerals and other substances necessary for adequate nutrition of animals of various age categories and intended use. The program contains a certain basic number of food rations, based on data taken from the reference manual "Norms and rations of feeding farm animals", published in Moscow in 2003 under the auspices of the Ministry of Agriculture of the Russian Federation, the Russian Academy of Agricultural Sciences and the All-Russian State Research Institute of Livestock ... In addition, it is possible to edit existing and add new food rations. The user interface of the process for working with the list of diet types is shown in Figure 2.

Diagram

Description automatically generated

Figure 2 - Working with the list of types of rations

2) Preparation of lists of feeds indicating the content of vitamins, minerals and other substances that are important for feeding animals (Figure 3).

Graphical user interface, table

Description automatically generated

Figure 3 - Working with the list of feeds

The program also contains a certain basic amount of feed, indicating the required parameters. The possibility of editing and adding new feeds is provided.

3) The final stage of working with the software is the selection of the required ration, available feed and the direct preparation of the ration based on the selected parameters. The software, according to the compiled calculation algorithms, tries to select the required amount of the specified feeds to compile the required ration according to the specified nutritional parameters (Figure 4). If it is impossible to compose a full-fledged diet, the program will inform the user about this, indicating the values ​​of the parameters required for this diet.

Table

Description automatically generated

Figure 4 - Preparing the calculation of recipes for feeding rations

The developed software is distributed between farms of various forms of ownership and is undergoing a testing stage in order to identify inaccuracies in the operation of the program algorithm.

# 4 Research results

In accordance with the overall goal of the project and the task set for the reporting period, the following was accomplished:

The analysis of the current state and level of development in the Republic of Kazakhstan of the pig industry; analysis of the number of pigs by sex and age groups; the structure of the pork producers' market was investigated; analysis of problems in the development of pig breeding and identified the main problems of low productivity of animals; a forecast for the production, consumption, import and export of pork and the development of the pork industry was prepared.

Tasks for the next period are distributed among the members of the working group, the terms of their implementation, methods and forms of interaction and the expected results are discussed.

The article "Automatic pig feeding system: Efficiency" was prepared and accepted for publication in the peer-reviewed scientific journal Pakistan Journal of Zoology (ISSN 00309923, Q3, percentile 43, https://researcherslinks.com/journal/Pakistan-journal-of -zoology / 20).

The aims of the article are:

- Consideration of the main factors and aspects characterizing the industry problems associated with the use of outdated "typical" projects and equipment.

- Development of proposals for the introduction of progressive technologies for raising and fattening pigs, including a system of interrelated measures for keeping and feeding animals, maximum mechanization and automation of all production processes.

The relevance of the topic lies in the development of a network of feed stations associated with a personal computer for convenient control. State-of-the-art interfaces allow remote maintenance and connection to pig planning databases is also possible.

Each feeding station is equipped with a controller and related equipment that identifies the animal, determines the rate and the feeder to which it feeds. The feeder is equipped with a device for accurate dosing of medications, designed for 5, 10 liters, automatic wetting of feed directly in the feeder (combined feeding is possible: crushed corn, whey.

The novelty of this research lies in the development of an automatic feeding system for pigs, which allows for continuous and accurate accounting of the feed freely consumed by each individual animal in group maintenance.

The man sources include:

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2)               Zagorovskaya V., Chernyshova E. Feed balance. Main trends in pig feeding / V. Zagorovskaya, E. Chernyshova // Information portal "Agrotechnics and technologies" - September 13, 2019. - https://www.agroinvestor.ru/technologies/article/32409-kormovoy-balans/;

3) Asaubaev R.Sh., Polyak A.I. Analysis of the pig industry in Kazakhstan for 10 years / R.Sh. Asaubaev, A.I. Pole // Information portal "News.myseldon.com" - 04/21/2020 - https://news.myseldon.com/ru/news/index/228148612;

4) Website of the statistics committee;

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The article "Rational use of feed as a factor in the growth of animal productivity in pig farms" was published in the journal "Problems of the agricultural market".

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10)          Dambaulova G.K., The Role of Information-Consulting Service in Efficiency Increasing of the Use of Limited Resources in the Agrarian Enterprises. The Social Sciences 11 (10): 2617-2620, ISSN: 1818-5800, Medwell Journals, 2016.

Criteria have been developed to optimize rations with a flexible process of animal feeding for maximum production efficiency in various production and economic situations. A test version of the program for calculating the ration of feeding pigs was developed, the program was recorded and distributed between farms of various forms of ownership.

# CONCLUSION

According to the general purpose of the project and the adage set by the reporting period, and in accordance with the calendar plan, the following was accomplished:

1) Information is provided on the current state and level of development of the pig industry in the Republic of Kazakhstan; the analysis of the number of pigs by sex and age groups was carried out; the structure of the pork producers' market was investigated; a forecast for the production, consumption, import and export of pork and the development of the pig industry was prepared.

2) The main factors and aspects characterizing the sectoral problems, including those related to the use of outdated "standard" projects and equipment are given.

3) Provides information on the main technological parameters of the operation of pig farms of various capacities.

4) A general research methodology, an approximate algorithm, directions, stages of its implementation and the timing of each stage have been developed.

5) Assignments for the next period are distributed among the members of the working group, the terms of implementation, methods and forms of interaction and expected results are discussed.

6) The article "Automatic pig feeding system: Efficiency" was prepared and accepted for publication in the peer-reviewed scientific journal Pakistan Journal of Zoology (ISSN 00309923, Q3, percentile 43, https://researcherslinks.com/journal/Pakistan-journal-of-zoology/20 ).

7) The article "Rational use of feed as a factor in the growth of animal productivity in pig farms" was published in the journal "Problems of the agricultural market".

8) Software for calculating rations for pigs was developed.

In general, the tasks planned for the reporting period were completed in full.

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# APPENDIX A

**Implementation work plan**

**CALENDAR PLAN**

1. Non-profit joint stock company "Kostanay Regional University named after A. Baitursynov"

1. Priority: Sustainable development of the agro-industrial complex and safety of agricultural products
2. Sub-priority: Development of intensive livestock production.
3. The topic of the project: IRN AR08956964 "Efficiency of digitalization of feeding processes in pig breeding "
4. The total funding of the project is 4,995,690 (four million nine hundred ninety-five thousand six hundred ninety) tenge, with a breakdown by years, for the performance of tasks in accordance with clause 3:

2. The characteristics of scientific and technical products by qualifications and economic indicators

* for 2020 - in the amount of 3,000,000 (three million) tenge.
* for 2021 - in the amount of 1 995 690 one million nine hundred ninety-five thousand six hundred ninety) tenge.

1. The direction of the project: Theoretical justification of the need for intensive development of pig breeding in the Kostanay region. Based on its results, the development of recommendations of methodological and practical significance for the introduction of digital technologies in the feeding processes of pigs, ensuring high quality of pig breeding products and increasing its competitiveness in the border market in the context of interregional spatial integration of Russia and Kazakhstan.
2. The scope of the project: economics and organization of agriculture, accounting, and analysis of economic activities of agricultural enterprises.
3. End results:

* for 2020: The analysis and systematization of the main problems in the development of pig breeding in the Kostanay region under modern economic conditions were carried out. The preferential directions of the sequential intensification of individual processes of the production of pig-breeding products were justified.
* for 2021: The relationship between the rations of feeding pigs and the quality of pig products has been established. The choice of an effective feeding strategy as a primary task of a pig-breeding enterprise has been substantiated. One article or review has been published in a peer-reviewed scientific journal included in the first), second), third or fourth quartiles in the Web of Science database and / or having a SiteScore percentile in Scopus database not less than thirty-five or is in print in the specified editions, as well as one article in a peer-reviewed foreign and (or) domestic edition with a nonzero impact factor (recommended by CCSES). Practical recommendations have been developed for the implementation of digitalization in the feeding processes in pig breeding. A program has been developed for calculating the ration of feeding pigs.

1. Patentability: No.
2. Scientific and technical level (novelty): Currently, in the structure of Kazakhstani livestock breeding, the most "lagging" industry is pig breeding, which is explained, first of all, by the lack of an organized sales market for products of pig industry in our country. However, in the context of the development of interregional spatial integration of Russia and Kazakhstan, the effective organization of the production of pig products can make an important contribution to the development of export trade organized between the border areas of both countries. In this regard, the expected results of the project are guidelines for solving economic and organizational problems associated with the need to reduce costs and improve the quality of products of pig farms. The results of the project will be of interest both for households engaged in auxiliary pig breeding and for organizers of large pig breeding farms as potential exporters who, in the future, plan to actively participate in cross-border trade.
3. The use of scientific and technical products is carried out by the following actors: Agricultural industry of the Republic: livestock farms, private farmsteads, as well as the Veterinary Directorate, the Agriculture Directorate, the Ministry of Agriculture of the Republic of Kazakhstan.
4. Type of the utilisation of the result of scientific and (or) scientific and technical activities: The results of research project will be available in the form of scientific publications.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Task code, stage | | The name of the task under the Agreement and the main stages of its implementation | Deadline\* | | Expected result |
| Start | Finish |  |
| 2020 | | | | | |
| 1 | | To analyze and systematize the main problems in the development of pig breeding in the Kostanay region under modern economic conditions. (Working with statistical data and conducting a survey) | October 2020 | December 2020 | An analysis and systematization of the main problems in the development of pig breeding in the Kostanay region under modern economic conditions (working with statistical data and conducting a survey). Also, an analysis of the development of the pig industry in the region and in the Republic of Kazakhstan. Additionally, factors that restrain the intensive development of pig breeding will be establishe, negative trends will be identified, causing a decrease in the profitability of the production and sale of pig products. |
| 2 | To substantiate the preferential directions for the consistent intensification of individual processes to produce pig products. | | November 2020 | December 2020 | The preferential directions for the consistent intensification of individual processes to produce pig products. |
| 2021 | | | | | |
| 3 | To justify the preferential directions of the sequential intensification of certain processes of production of pig-breeding products (conducting a roundtable discussion). | | January 2021 | January 2021 | Aspects will be developed to ensure the growth of pig production, competitiveness in the market agricultural products of the Russian-Kazakh border area; intensification of animal husbandry. |

Continuation of the table

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| 4 | To establish the relationship between the rations of feeding pigs and the quality of pig products (Writing and publishing an article in the journal “Problems of the agricultural market”). | February 2021 | March 2021 | The established relationship between the rations of feeding pigs and the quality of pig products; developed technologies for keeping and feeding pigs. A published article in the journal “Problems of Agricultural Market” (CCSES). |
| 5 | To justify the choice of an effective feeding strategy as a primary task of a pig breeding enterprise (Writing and publishing an article in Scopus). | April 2021 | May 2021 | A justified choice of an effective feeding strategy based on the main principle such as obtaining maximum profit at minimum costs. One published article or review in a peer-reviewed scientific publication included in the Web of Science database and (or) having a SiteScore percentile in the Scopus database of at least thirty-five or in print in the indicated editions. |
| 6 | To develop practical recommendations for the implementation of digitalization in the feeding processes in pig breeding (Issue and dissemination of recommendations between farms of various forms of ownership). | June 2021 | July 2021 | Developed practical recommendations for implementation of digitalization into the feeding processes in pig breeding with the subsequent release and distribution between farms of various forms of ownership. |

Continuation of the table

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| 7 | To develop a program for calculating the ration of feeding pigs. To write a report (Recording and distribution of the program between farms of different forms of ownership) | August 2021 | September 2021 | Developed criteria to optimize rations with a flexible feeding process for maximum production efficiency in various production and economic situations. A developed program for calculating the ration of feeding pigs. Final report. The recorded and disseminated program among farms of various forms of ownership. |